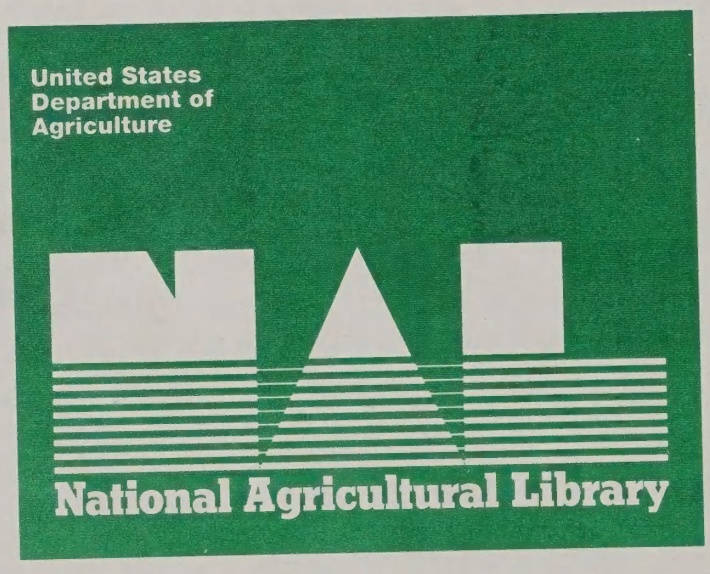
Inspectional Requirements for Green Bananas from Hawaii

1998

Risk Analysis Systems
Policy and Program Development
APHIS, USDA


United States
Department of
Agriculture
National Agricultural Library

Inspectional Requirements for Green Bananas from Hawaii

Charles "Ed" Miller and Lorene Chang
Risk Analysis Systems
Policy and Program Development
Animal and Plant Health Inspection Service
U.S. Department of Agriculture
Riverdale, MD

September 1998

Mention of producers does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned. USDA neither guarantees nor warrants the standard of any product mentioned. Names are mentioned solely to report factually on available data and to provide specific information.

Executive Summary

Animal and Plant Health Inspection Service (APHIS) and Agricultural Research Service (ARS) conducted a study in 1996-97 to establish criteria based on pest risk for Plant Protection and Quarantine (PPQ) to inspect and clear green bananas (*Musa acuminata* Colla) moving from Hawaii to the continental United States. To accomplish this objective, PPQ in Hawaii sampled intrastate shipments of green bananas to determine the frequency and distribution of faults (i.e., bruises, splits, partly ripened fruit) in export quality bananas. PPQ surveyed for a year the four commercial cultivars in Hawaii: dwarf 'Brazilian' and the three Cavendish cultivars—'Grand Nain', 'Valery', and 'William's'.

ARS' research on banana culls from various packing houses identified those faults that the three fruit fly species of concern could infest naturally. The three species included Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), oriental fruit fly, *Bactrocera dorsalis* (Hendel), and melon fly, *Bactrocera cucurbitae* Coquillett. ARS also determined the naturally occurring fruit fly infestation rates for various faults by holding the culled bananas.

Faults included various types of injured or aberrant fruit. Fault types that were susceptible to fruit fly infestation were considered serious faults. Serious faults included fused fingers, precociously ripening fruit (one finger ripening before the others in the same cluster), and fruit with flesh exposed by an injury in the field (injuries during harvest and packing are not susceptible immediately). Other fault types included abrasions, point bruises or scars, and ant burns were not considered serious faults. Fruit flies infested only those faults where an opening exposed fruit flesh.

The occurrence of faults is currently rare for unregulated commercial shipments. The probability of a banana having a serious fault in one of these shipments was 0.000343 or one fault for every 2,914 banana fingers. Serious faults are easily observed and removed by the packers before inspection by PPQ. This removal and strict regulation by PPQ will further reduce fault occurrence in an export shipment to levels lower than 0.000343.

Few quarantine pests were recovered. Three species have Federal quarantine status. One Federal quarantine pest was the oriental fruit fly (the only fruit fly species recovered from the bananas). It infested about 1-3 percent of the culled fruit with faults. The second pest [a banana moth, *Opogona sacchari* (Bojen)] was reared from 2 percent of the culls. The third quarantine insect species (green scale, *Coccus viridis* Green) was found in one of the total of 52 shipments surveyed. None of the three fruit fly species nor banana moth was recovered from commercial shipments of sound fruit with no faults.

Non-Federal quarantine pests may cause problems with California quarantine officials. A quarantine pest for California—coconut scale, *Aspidiotus destructor* Signoret—was commonly found on shipment quality fruit. Although risk of establishment from consumption fruit would be low, this insect will probably be the most significant problem for the Hawaiian grower shipping to a California port. Other pests that may pose a quarantine problem for California State or county officials were occasionally found during the survey of shipments. They included worker ants, cockroaches, sowbugs, earwigs, and several scale insect species.

For a 5,000-fruit shipment and a sample size of 440 fingers, the number of fruit with serious faults infested by fruit flies that escape detection is estimated as 0.0432 or one in 115,741 'Brazilian' bananas and 0.0207 or 1 in 241,546 Cavendish bananas. A 440-fruit sample gives 95 percent confidence of detecting fruit with serious faults occurring at a 0.6 percent rate or greater in a shipment. A 220-fruit sample will detect serious faults that occur at a 1.3 percent rate or greater. Increasing the sample size to 880 fruit has little effect on increasing the rate of finds of faults.

Based on pest risk, the criteria for PPQ to inspect and clear green bananas from Hawaii to the continental United States include:

- a sample size of 440 fruit in a 5,000-fruit shipment for predeparture inspection. Sample size may be reduced to 220 fruit with the continued absence of serious faults for a specific grower.

- APHIS maintaining frequent communication with the growers in Hawaii to ensure growers understand Federal requirements, especially that PPQ will reject shipments if one or more serious faults are found in a shipment.

Acknowledgments

We thank Dr. John W. Armstrong and Steven A. Brown at the U.S. Department of Agriculture's ARS Tropical Fruit, Vegetable and Ornamental Crop Research Laboratory in Hilo, HI, and Edward T. Uyeda (Officer In Charge) and the PPQ officers at Hilo for conducting the survey and research for this project. Also, we thank Dr. Victor C. Beal, Jr., Veterinary Services, APHIS, Riverdale, MD, for his suggestions and help with the risk assessment and statistical portions of this project, and Pete Grosser and Edwin M. Imai, PPQ, Riverdale, MD, for document review and their suggestions during this project.

Contents

Introduction

Objective

This project on banana, *Musa acuminata* Colla, shipments from Hawaii had two objectives. The first was to characterize the faults that harbored quarantine pests, which Plant Protection and Quarantine, Animal and Plant Health Inspection, U.S. Department of Agriculture (PPQ, APHIS, USDA) would reject in a shipment of green bananas to the continental United States. The second objective was to determine the appropriate sample size per shipment to ensure detecting these faults if they were present.

Background

In late 1995, the Port Operation staff of PPQ asked Risk Analysis Systems (Policy and Program Development, APHIS) to assist in obtaining this information. Previously, Hawaiian banana growers had indicated an interest in exporting commercial shipments of green bananas to the continental United States. Current Federal quarantine regulations prohibit movement of banana fruit from Hawaii to other U.S. areas because of the presence in Hawaii of Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), oriental fruit fly, *Bactrocera dorsalis* (Hendel), and melon fly, *Bactrocera cucurbitae* Coquillett. These pests are known to infest banana fruit under certain conditions. Earlier, Agricultural Research Service (ARS), USDA, indicated that Armstrong (1983) had demonstrated that green bananas under certain restrictions should be admitted without treatment to the continental United States. (See appendices A and B.) Some of these restrictions specified that fruit should be free of bruising and that cultivars only include 'Brazilian,' 'Valery', and 'William's'.

A review of the literature showed that little information existed on the

- frequency and distribution of faults (i.e., bruises, splits) in export quality bananas, and
- naturally occurring fruit fly infestation rates of bananas with these faults.

The above information would be needed to establish inspection and rejection criteria based on risk. PPQ in Hawaii agreed to sample intrastate shipments of green bananas to characterize them for faults. ARS agreed to determine the naturally occurring fruit fly infestation rates for bananas with various faults by collecting and holding culled bananas from various packing houses in Hawaii. (See appendix C.)

Definitions

Banana (parts are described, progressing from a single fruit to the entire inflorescence)

- Finger—a single banana fruit
- Finger stalk—the pedicel or short stalk attaching a finger to the crown
- Crown—the crescent-shaped structure joining the finger stalks of the hand to the axis of the bunch
- Hand—a group of fingers attached by their crown to the main stalk, forming a distinct unit of the bunch
- Cluster—several fingers cut from a hand that are still held together by their crown
- Bunch—the whole inflorescence bearing all the hands
- Stalk—axis of the bunch

Commercial #1—ripeness stage 1 of bananas, generally free of defects and faults with the longitudinal ribs apparent but not prominent, also referred to as export quality.

Cull—damaged or aberrant fruit removed from harvested bananas at the packing house. Culls do not meet marketing standards and detract from the commercial quality of the shipment.

Cull dump—open container where culled bananas are left to accumulate at the packing house.

Cultivar—a plant cultivated for one or more horticultural or agricultural characters differing from the usual characters of its species and generally designated by a fancy epithet.

Fault—fruit having a defect on the peel (naturally occurring or mechanically caused injury) or defect in color or shape (aberrant fruit precociously ripened or deformed). Appendix E lists these faults.

Fused fingers—banana fingers that are joined to one another longitudinally

Ripeness stage—Described by color reference charts commonly used by the banana industry

Stage	Banana Peel Color
1	Green or dark green (depending on the chart used)
2	Green with trace of yellow around the finger stalk, or light green
3	More green than yellow
4 to 7	More yellow than green, to yellow with brown spots

Serious fault—a fault susceptible to fruit fly infestation. See discussion on page 5 under Hazard Identification.

Shipment size—about 5,000 fingers in a typical shipment, comprising 40 to 50 boxes.

Methodology

Several studies were conducted on bananas to obtain the necessary information: (1) inspection of commercial shipments to determine the types and numbers of faults and pests, (2) holding of cull bananas to determine the fault types susceptible to pests, and (3) host studies.

Survey Design for Commercial Shipments

PPQ surveyed commercial shipments of bananas grown and packed in the Hilo area of Hawaii Island from September 1996 to August 1997. The survey included only commercial #1 green bananas of the four cultivars commercially grown in the State. The four banana cultivars are dwarf 'Brazilian' (the standard 'Brazilian' is no longer commonly grown in Hawaii) and the three Cavendish cultivars: 'Grand Nain', 'Valery', and 'William's'.

The PPQ officer selected 10 boxes from each shipment to inspect for faults (injuries and ripeness faults of ripeness stage 3 or riper) and pests. In nine boxes, the officer inspected all the fruit (fingers) in the top layer of clusters (each cluster has from three to seven fingers). In the tenth box, the officer inspected the bottom layer of clusters and the bottom of the box for hitchhiking insects. Bananas found with serious faults were given to ARS to determine if the fruit were infested. Records for each grower and for each inspection were completed by the PPQ officers. (See appendix D.) Records were kept on the cultivars, insects found, and number and kind of each fault found.

Collection and Holding of Cull Samples

During the same period, bananas with faults were collected from cull dumps. Cull dumps are open to insect entry. Weekly cull samples were collected from six packing houses in different areas of the Puna District near Hilo on Hawaii Island. Additional cull samples were collected from the islands of Kauai, Maui, Molokai, and Oahu. All four banana cultivars were collected, but the three Cavendish cultivars, 'Grand Nain', 'Valery', and 'William's', were recorded only as Cavendish. These culls were individually held by ARS to recover insects. All insect species found were recorded for each fault type.

Host Studies

ARS conducted other field and laboratory studies, mainly on the dwarf 'Brazilian' cultivar. A major objective was to determine if sound green fruit of the dwarf 'Brazilian' was a host of the fruit flies occurring in Hawaii. Armstrong (1983) had previously shown that the other cultivars: standard 'Brazilian' and Cavendish ('Valery' and 'William's') in the mature green stage were not hosts for the three fruit fly species in nature. More information on the cull sampling methodology or on the other studies will be available in Armstrong's Technical Report on this subject (Draft 1998).

Analysis

Survey and Research Results

Survey Results of Commercial Shipments

Details of the PPQ survey of commercial shipments are summarized in appendix F in five tables. Table I describes the 10 growers surveyed on Hawaii Island. Shipments from grower number 5, who had the largest production acreage, were inspected more frequently. Table II lists for each of the 52 shipments inspected: the presence of pests, possible banana tip rot, and serious faults. (See discussion of serious faults on page 5 under Hazard Identification.)

Table III identifies the Federal and State of California quarantine status of the various organisms collected. The one certain Federal quarantine pest identified was green scale, *Coccus viridis* (Green), in one shipment. An adult moth collected was not identified, leaving its quarantine status unknown. Coconut scale, *Aspidiotus destructor* Signoret (found in 24 of the shipments) is a quarantine pest for California.

Table IV summarizes the numbers of shipments, clusters per box, and fruit inspected by type; and the destination of the shipments. Table V identifies the serious faults found by PPQ in the commercial shipments surveyed and also indicates the banana type and the destination of each shipment with a serious fault.

Cull Research Results

Appendix H, tables I and II summarize the results of the culled-banana research conducted by ARS. Culls totaled 8,751 and 2,417 fruit (fingers), respectively, for dwarf 'Brazilian' and Cavendish. Fruit flies infested 1.03 percent of the dwarf 'Brazilian' fruit and 0.79 percent of the Cavendish. The only fruit fly recovered from the bananas was the oriental fruit fly. Besides fruit flies, banana moth, *Opogona sacchari* (Bojen), was recovered from 1.85 percent of the dwarf 'Brazilian' fruit and 2.11 percent of the Cavendish fruit. Both tables list the data on the above pests by fault types.

Assessment

Scope

One of the objectives of this paper is to determine the appropriate inspectional requirements for shipping green bananas from Hawaii to the continental United States. The scope of this assessment is thus limited to determining the likelihood of a commercial shipment being infested under the current unregulated conditions. Estimating the likelihood of fruit fly introduction and establishment via this pathway into the continental United States is not required to accomplish this objective. Other pests found associated with banana fruit during PPQ's survey or ARS's research are discussed but not formally assessed. The consequence of introducing the main pests of concern, fruit flies, has been documented elsewhere and is outside of the scope of this paper.

Hazard Identification of Faults

Another objective of this project was to identify those faults of banana fruit in commercial shipments that one of the fruit flies of concern could infest. ARS conducted the research on banana culls to aid in this determination. After a review of the results (see appendix H) and discussions with Armstrong, we considered the following faults susceptible to fruit fly infestation. These faults are referred to as serious faults.

- Precociously ripening fruit
- Fruit flesh exposed by cuts, splits, punctures, cracks, bird pecks, crushing, or bent stems. Susceptible cuts include only those made in the field during the growing stage, not cuts made during the packing process.
- Deformed fruit (or fused fingers)—Although only one fruit was infested in this group, the sample was so small [especially for the Cavendish cultivars (14 bananas)] that this fault is included as a serious fault.

Fruit flies infested cull bananas with other fault types: abrasions, point bruises or scars, and ant burns. (See appendix H.) Abraded and point-bruised fruit were infested only where these injuries exposed fruit flesh. Infested fruit classified under ant burns were likely to have had other faults. Also, infestation rates were low for all cultivars with these fault types: abrasions—10 infested fruit in 1,990 abraded fruit, point bruises—6 infested in 1,587 fruit, and ant burns—2 in 492 fruit. Fruit used for this test were from cull dumps. For these reasons, these three fault types are not considered serious faults.

Likelihood of Occurrence of Infested Fruit Per Shipment

$$F_1 \times P_1 \times P_2 \times P_3 = F_2$$

The simple linear model above was used to estimate the risk where:

F_1 = fruit per shipment
F_1 is assumed to be 5,000 fruit per shipment and is considered a typical shipment size for growers in Hawaii. A shipment would comprise 40 to 50 boxes. The largest grower in the survey had as many as 384 boxes in a shipment. (See appendix F, table II).

P_1 = probability that serious faults occur in banana fruit inspected
P_1 is estimated as 0.000343 or 8 faults in 23,308 bananas. (See appendix F, tables V and IV). The rate of faults per shipment is assumed to be determined by how carefully the packers cull faults, not by which cultivars are involved; thus all cultivars were pooled for one rate.

P_2 = probability that faults escape detection during inspection
P_2 is estimated by using the hypergeometric formula for each cultivar type for various sample sizes. (See explanation of P_2 on page 6 for details.)

P_3 = probability that fruit flies infest faults
P_3 is estimated in table 1 by using the infestation data from appendix H for serious faults as defined above in the Hazard Identification section.

F_2 = frequency per shipment of infested fruit escaping detection
The results, F_2, are shown in table 2.

Table 1. Fruit Fly Infestation Rate in Collected Banana Culls

Fault type	Number of fingers with faults			
	Dwarf 'Brazilian'		Cavendish	
	Infested	Collected	Infested	Collected
Cut	7	608	0	298
Split	1	115	3	160
Crushed	4	172	4	182
Precocious ripening	53	224	5	31
Puncture (through skin)	1	574	0	160
Crack (through skin)	6	251	0	10
Bird peck	0	1	0	3
Fused fingers	0	391	1	14
Stem bend	8	378	0	63
Total	80	2714	13	921
Rate (infested/total)	0.0295		0.0141	

Table 2. Frequency of Fruit Fly-infested Fruit per Shipment

Scenario: Fingers sampled Banana type	Fruit per shipment F_1	×	Fruit has fault P_1	×	Fault is not detected P_2	×	Fault is infested P_3	=	Infested fruit per shipment F_2
Standard sample									
• 440 fingers each									
'Brazilian'	5000	×	0.000343	×	0.854	×	0.0295	=	0.0432
Cavendish	5000	×	0.000343	×	0.854	×	0.0141	=	0.0207
Alternative samples									
• 220 fingers each									
'Brazilian'	5000	×	0.000343	×	0.926	×	0.0295	=	0.0468
Cavendish	5000	×	0.000343	×	0.926	×	0.0141	=	0.0224
• 880 fingers									
'Brazilian'	5000	×	0.000343	×	0.718	×	0.0295	=	0.0364
Cavendish	5000	×	0.000343	×	0.718	×	0.0141	=	0.0174

where

F_1 = assumed typical shipment size

P_1 = probability of a serious fault occurring in all inspected bananas ($\frac{8}{23308,}$ data from appendix F, tables V and IV, respectively)

P_2 = probability that the fault is not detected in the fruit sampled. For a total population of 5,000 and a threshold prevalence of 0.000343 (P_1), the hypergeometric formula indicates that (read table horizontally)

for a fruit sample of	detecting a fault has the probability	so its converse gives the probability of not detecting the fault (P_2)
fingers		
440	0.146	1 - 0.146
220	0.0741	1 - 0.0741
880	0.282	1 - 0.282

P_3 = probability that a fault is infested. This is the ratio of the number of infested fruit to the number of faults for 'Brazilian' ($\frac{80}{2714}$) and for Cavendish ($\frac{13}{921}$). See table 1 and text.

F_2 = estimated frequency per shipment of infested fruit escaping detection

Uncertainty

Because point estimates were used for the various parameters, no quantitative estimate of uncertainty is available. Because P_2 is a statistical inference and the data for P_1 and P_3 are taken from results of a survey and research specifically designed for this use, the estimates used have a high degree of certainty.

Discussion

Fruit Flies

Armstrong's (1998) research completed on banana culls indicated that green bananas from Hawaii with certain faults represent a significant risk for fruit flies, especially for oriental fruit fly. These serious faults include precociously ripening fruit, fruit with exposed flesh, and fused fingers. The results of PPQ's survey of unregulated commercial shipments indicated that the occurrence of these faults is currently rare. The probability of a banana having a serious fault in one of these shipments was 0.000343 or one fault for every 2,914 fruit.

The faults that have been identified as serious (given above) are easily observed by the packers. Strict regulation by PPQ would reduce the occurrence of these faults in the export shipment to levels lower than the 0.000343 estimate. Careful growers would cull these faults if they knew that inspections for these faults would occur and that one or more serious faults would cause rejection of the entire shipment. Given these factors, the actual frequency or likelihood of an infested fruit being in a shipment would be much lower than that calculated in table 2.

Table 2 shows that increasing the sample size for regulatory inspection from 220 to 880 fruit has little effect on the estimated frequency of infested fruit per shipment escaping detection. That is a result of the rarity of fruits with faults. A substantial sample size may be needed to quickly identify careless growers. Note that although most fruit with serious faults found during PPQ's survey of commercial shipments were held by ARS, no serious faults in the shipments were found infested with fruit fly. (See appendix F, tables III and V.) Serious faults were found only on eight fingers.

Other Organisms

- The banana moth was routinely reared from the culled fruit (Armstrong 1998). About 2 percent of the culls were infested with an average of two larvae per infested fruit. No moths were recovered in any of the tests that ARS completed with sound fruit that had no faults (Armstrong 1998). The banana moth was not found during PPQ's survey of shipment quality fruit, but the inspection did not hold or cut fruit with tip rot. (The blossom end of the fruit exhibits a nipple-shape deformity.) This rot is caused by a widely distributed pathogen and sometimes associated with the moth. (See appendix F, table II.)

  The banana moth is a Federal quarantine pest. The moth occurs widely in tropical and subtropical regions including South and Central America, the Caribbean, and Florida since 1986. Smith et al. (1997) stated that this pest can have an economic impact on bananas and woody ornamentals in tropical and subtropical areas, and can become a glasshouse pest elsewhere. With the major risk of introduction from imported planting material, banana fruit constitutes a low risk. PPQ interception records on banana fruit from the neotropics also suggest the same low risk. Banana moth in Hawaiian banana fruit is, therefore, expected to rarely occur in commercial shipments.

- Coconut scale, commonly found on shipment quality fruit during PPQ's survey, is widely distributed in the tropics, occurs in Florida, and has previously been reported from at least one location in California (Commonwealth Institute of Entomology 1966). This scale is not a Federal quarantine pest, but it is a quarantine pest for California. Although the risk for establishment of this tropical, sessile insect from consumption fruit would be low, this insect will probably be the most significant problem for the Hawaiian grower shipping to a California port.

- Other pests infrequently found by PPQ during the survey of shipment-quality fruit (worker ants, cockroaches, sowbugs, earwigs, and other scale insects) may or may not cause quarantine problems with California State or county officials. Green scale was the only Federal quarantine insect species found during the PPQ survey. (See appendix F, table III).

Recommendations

Based on this document, Royer (1992), and the research conducted by Armstrong (1983, draft 1998), green bananas from Hawaii shipped under the requirements proposed in the Federal Register (63: 31675-31678; 1998) pose no significant risk to continental U.S. agriculture.

To ensure that these requirements are met,

- The sample size for predeparture inspection should be approximately 440 fingers or fruit (from about 7 clusters per box from 10 boxes) at the startup of the program and for new exporters. The sample size can later be reduced to 220 fruit for individual growers who consistently present shipments with no serious faults.

- The 440-fruit sample gives a 95 percent confidence level of detecting serious faults occurring at a 0.006 (0.6 percent) rate or greater in a shipment of 5,000 fruit. The 220-fruit sample gives a 95 percent confidence level for detecting serious faults that occur at a 0.013 (1.3 percent) rate or greater.

- APHIS should meet with the growers in Hawaii before export shipments begin. APHIS needs to ensure that the growers understand Federal requirements, especially that PPQ will reject the entire shipment if one or more serious faults are found in a shipment. The growers also must understand the Federal and California quarantine status of organisms that may be intercepted with these shipments.

References

Armstrong, J. W. Infestation biology of three fruit fly (Diptera: Tephritidae) species on 'Brazilian,' 'Valery,' and 'William's' cultivars of banana in Hawaii. J. Econ. Entomol. 76(3): 539-543; 1983.

__. Quarantine security of bananas at harvest maturity against Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) and oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) in Hawaii. Draft Technical Report. [1998].

Commonwealth Institute of Entomology. Distribution maps of pests: *Aspidiotus destructor* Sign. Series A, No. 218. London: Commonwealth Agricultural Bureaux; 1966.

Plant Pest Diagnostics Center Program (PPDCP). Entomology records program dictionary and ratings list. [Sacramento, CA: California Department of Food and Agriculture]; June 1, 1995.

Royer, M. H. Bananas from Hawaii [Letter to M. Shannon]. 1992 November 3. Located in: Pest Risk Assessment Files - *Musa*, Scientific Services, Plant Protection and Quarantine, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Riverdale, MD.

Smith, I. M.; McNamara, D. G.; Scott, P. R.; Holderness, M., editorial committee. *Opogona sacchari*. Quarantine pests for Europe: data sheets on quarantine pests for the European Union and for the European and Mediterranean Plant Protection Organization. 2d ed. Wallingford, Oxon, UK: CAB International in association with the European and Mediterranean Plant Protection Organization; 1997: 414-417.

Appendix A

United States Department of Agriculture | Agricultural Research Service | National Program Staff | Beltsville, Maryland 20705

MAR 13 1992

February 18, 1992

SUBJECT: Recommendation on Importation of Hawaiian Bananas to U.S. Mainland

TO: Charles Schwalbe
Director, Operations Support
PPQ, APHIS

FROM: Ken Vick, National Program Leader
Plant Quarantine and Stored Product Insects

I was requested by copy of a memo from Peter Witherell to you dated November 27, 1991, to make a formal recommendation on the question of allowing bananas from Hawaii into the U.S. mainland. This is to inform you that I concur with Mr. Witherell that based on the work of ARS scientist Dr. Jack Armstrong and with the provisions enumerated by Mr. Witherell (varietal restrictions, stage of ripeness restrictions, freedom from bruising, commercial shipments only, and PPQ certification of each shipment) bananas should be admitted to the U.S. without treatment.

cc:
W. Martinez, ARS
P. Witherell, APHIS
N. Leppla, APHIS
R. Berninger, APHIS

Agricultural Research Service

FEB 24 1992

Appendix B

United States Department of Agriculture | Animal and Plant Health Inspection Service | Science and Technology | Hoboken Methods Development Center, 209 River Street, Hoboken, NJ 07030

Subject: Bananas from Hawaii to the U.S. Mainland

Date: November 27, 1991

To: Dr. C.P. Schwalbe, Director, OS, PPQ
Thru: Dr. N.C. Leppla, Director, Methods Development, S&T
Thru: Dr. R.W. Berninger, Director, Hoboken MDC

We have had the opportunity to analyze the Hawaiian proposal to ship bananas to the U.S. mainland, including a petition from the East Hawaii Banana Cooperative, two research papers by Dr. J. Armstrong (USDA-ARS), internal APHIS memoranda written by J.R. Reynolds (9/20/91) and C.P. Schwalbe (10/15/91), decision sheets on bananas written by PPQ-BATS, and file data available from our quarantine treatment library in Hoboken. We have also received several calls in the past several weeks from prospective Hawaiian exporters.

We note that since the loss of EDB several years ago as a quarantine treatment, Hawaiian bananas have been allowed to enter the continental U.S. only at Alaska, where the risk of fruit fly outbreaks are non-existent. At the same time, the U.S. currently imports large numbers of bananas (without treatment) from several key tropical countries, notably Ecuador, Costa Rica and Mexico.

In-depth research by J. Armstrong (J. Econ. Entomol. 76:539-543 (1983)), has shown that green bananas cannot be considered to be a host in nature for any of the three major fruit flies of concern in Hawaii (Dacus dorsalis), D. cucurbitae, and Ceratitis capitata). I therefore recommend that APHIS should allow movement of Hawaiian bananas to the U.S. mainland, under the following conditions:

(1) Varietal restrictions: Exportation of Hawaiian bananas to the U.S. mainland should be restricted, at least initially, to the three cultivars included by Dr. Armstrong in his studies, namely 'Brazilian,' 'Valery' (=Taiwan), and 'William's' (=Giant Cavendish). Other varieties may be added at a later date, pending additional research data on fruit fly host preference/non-preference.

(2) Stage of ripeness restrictions: Bananas for movement to the mainland should be harvested in the "mature green" stage (stage 1). Upon packaging for shipment, they should be no riper than stage 2 (green with a trace of yellow). Some culling may be necessary to remove any fruits that have reached stage 3 or beyond.

Appendix B—Continued

C.P. Schwalbe, N.C. Leppla, R.W. Berninger

(3) Freedom from bruising: Since fruit flies may oviposit on bruised bananas, any such fruit must be culled before packaging for shipment.

(4) Commercial shipments only: Hawaiian bananas moving to the U.S. mainland must originate from packinghouses monitored by PPQ and should be containerized. No bananas should be allowed in passenger baggage from Hawaii.

(5) PPQ certification: PPQ must certify each shipment as to its being an approved variety, proper stage of ripeness, and freedom from apparent bruises. This document must accompany the shipper's invoice.

Before putting these procedures into effect, APHIS should first seek a formal recommendation from ARS (Dr. Ken Vick, Beltsville), then publish a proposed rule in the Federal Register.

It should be noted that bananas are quite intolerant of methyl bromide (MB) fumigation, though on several instances, APHIS has obtained a crisis exemption to fumigate bananas, using MB schedule T101A. Likewise, bananas are not tolerant to cold treatment. In the unlikely event that PPQ finds actionable pests accompanying Hawaiian bananas at the port of entry, the most reasonable course of action would be to refuse entry or destroy the shipment. If repeated incidents of this sort come to light, then I would recommend adapting a hot water dip treatment for bananas (15 minutes at 50°C, as outlined in an earlier paper by J. Armstrong, J. Econ. Entomol. 75:787-790 (1982).) Since no hot water dip facilities currently exist on the U.S. mainland, this treatment would have to be done in Hawaii.

Peter C. Witherell
Assistant Center Director

Appendix C

Hawaiian Bananas

MAR 2 9 1996

Ken Vick, National Program Leader
Agricultural Research Service
Beltsville, Maryland

This is to request ARS help in determining the appropriate sample size and selection method for the clearance of bananas from Hawaii to the U.S. mainland. Based on ARS recommendations, we plan to develop a proposed rule that would allow movement of bananas to the mainland.

To determine the appropriate sample size and selection method we need to determine: a. the frequency and distribution of faults (splits and bruises) in export quality bananas and, b. the naturally occurring fruit fly infestation rate of bananas with these faults. We plan to determine the frequency and distribution of faults by having APHIS inspectors sample banana shipments moving intrastate.

To obtain information to determine the naturally occurring infestation rate, we need your help. We are requesting personnel at the Hilo station rear out the fruit flies present in the bananas with faults. We estimate this project would occur over a 1-year period. The details of the project can be worked out by personnel from the Hilo station and our Port Operations staff. A site visit will be conducted to develop the protocol for sampling the bananas and procedures for delivering the bananas to the Hilo station. With your approval, we will make the necessary contacts and arrangements.

Please contact Jane Levy or Bud Petite deMange of our Port Operations staff at (301)734-8295 if there are questions concerning this request.

Sidney Cousins
Assistant Director
Operational Support
Plant Protection and Quarantine

APHIS:PPQ:JLevy:pa:03-25-96:734-8295:WP6.0-BANANA.FIN

Appendix D

Subject: Survey Design for Hawaiian Banana Shipments July 31, 1996

To : Ed Uyeda, Officer-in-Charge, Plant Pest and Quarantine, Hilo, Hawaii

Background

Based on a PPQ risk assessment and Agricultural Research Service (ARS) recommendations, APHIS plans to develop a proposed rule that would allow the movement of Hawaiian green bananas to the U. S. mainland. Because banana fruit under some conditions can be a host of serious quarantine fruit flies which occur in Hawaii (Mediterranean fruit fly and oriental fruit fly) the predeparture inspection procedures are critical. To determine the appropriate sample size and selection method for predeparture clearance of this product we need to determine: a) the frequency and distribution of faults (e.g. splits, bruises and partly ripened fruits) in expert quality bananas, and b) the naturally occurring fruit fly infestation rate of bananas with these faults. ARS will conduct research to determine the naturally occurring infestation rate. APHIS will conduct a year long survey of commercial shipments to determine the frequency and distributions of faults. Given below is the survey design.

Selection of Shipments

Two shipments should be selected per week for one year starting after ARS develops the definition and description of the various faults, thus **104 total shipments in survey**

Only commercial #1 quality green bananas destined to Honolulu, Maui or foreign locations should be included in survey. Hopefully at least ten growers will participate in the survey. (I do not believe that the one or two small farms located in the Kona area need to be included in our survey even if ARS includes them in theirs). Since Richard Ha's production represents about one half of the island's production, one-third (34 shipments) to one-half (52 shipments) of the sampled shipments should come from his farm. Since the other growers that would be expected to export to the mainland are all relatively small (five to 40 acres) about an equal number of shipments should be selected from each of them. Rotate the farms as best you can throughout the year so that if you survey Farmer A four times these surveys will be spread out throughout the year. For Richard Ha, you could inspect two shipments in one week from his place but than not select his shipments for the following one or two weeks.

Since four cultivars of bananas are commercially grown in Hawaii, all four should be sampled throughout the year. The following is suggested:

- 'Brazilians' at least 13 shipments and at least on every other week.

- Cavendish types 'Williams', 'Valery' and 'Grand Nain' cultivars
try to select each of these three cultivars equally throughout the year.
No one cultivar should be selected no fewer times than six.

Appendix D—Continued

Inspection of Shipment

Ten boxes from each shipment should be selected for inspection in a haphazard and unpredictable manner. The officer should not select all top boxes or the last ten boxes packed. In the first nine boxes, the officer should inspect all the fruit (fingers) in the top most level of clusters (each cluster has from three to seven fingers). For the cavendish type bananas this would be about six clusters or about 42 fingers per box. (Early on in the survey year your officers should come up with the average number of fingers per top level of cluster per box of cavendish and for the 'Brazilian'). In the tenth box, the officer should remove the top levels of clusters without inspection. The officer should then remove and inspect the bottom level of clusters and the bottom of the box for hitchhiking insects.

Bananas found with naturally occurring splits or of ripeness stage two or greater should be taken to ARS to confirm fault classification and possible further examination.

Record Keeping

Enclosed are two draft forms; one a farm data sheet and the other a shipment inspection record. Please comment if you think we need to modify these forms. Otherwise, we can start with these and modify them later if needed. The forms can be completed in ink by hand. I suggest that you fax me the first few completed forms (both shipment inspection records and farm data sheets) to make sure that we start off correctly.

The insect identification level needs to be the same as used in PPQ 309 forms. To the highest level for non plant pest groups (e.g., Blattidae "cockroaches", Staphylinidae "Rove Beetle", Nitidulidae "Sap Beetle", or Dermaptera "Earwing") or to the lowest possible level for possible quarantine pests.

Please comments on any aspect of the survey.

Charles E. Miller
Planning and Risk Analysis Systems
Policy and Program Development

Enclosure

Appendix E

United States Department of Agriculture
Animal and Plant Health Inspection Service
4700 River Road
Riverdale, MD 20737

February 10, 1997

Summary of ARS/APHIS Discussions on Research and Survey of Hawaii-Grown Bananas
January 21, 1997 - January 23, 1997

During the week of January 21, 1997, Peter Grosser and myself, APHIS, Riverdale, traveled to Hilo, Hawaii to review and discuss the current banana research and survey activities taking place there. The meetings and site visits to four banana packing houses were attained by Mr. Grosser; Ed Uyeda, Officer-in-Charge, Hilo, PPQ, APHIS; John W. Armstrong, Research Entomologist, Hilo, ARS; myself and as well as other USDA personnel at various times. The following issues were discussed: (Attached research protocol developed by ARS, Hilo are written in the past tense but are in progress and will be completed by about October 1997.)

Issue #1: Names and definitions of the faults standardized between ARS' cull samples research and PPQs' survey (inspections) of commercial banana shipments.

The workgroup agreed to use the following:

* Abraisons
* Ant burn
Bruise - this fault only affects skin
* Chemical burn
Crack (SD)1 or Crack (TS)2
Crushed - This fault is more than skin deep
Cut (SD) or Cut (TS)
Fused fingers - Two or more fingers fused together
Point bruise/scar
Pre-ripened - Precociously ripened fruit
Puncture (SD) or Puncture (TS)
Scale - Name the species if possible
Splits - Must be through the skin
Stem bend
* Sunburn
* Thrip damage
Tip rot or possible tip rot (for survey)
*Windburn

1. SD = skin defect
2. TS = fault that perforate the skin (through skin)

Those marked with an "*" are generally omitted from PPQs' survey reports. In addition, PPQ will not report Stage 1 (green) and State 2 (light green) on the reports.

Appendix E—Continued

Issue #2: Number per week of PPQ surveys.

It was agreed that one survey per week would be adequate.

Issue #3: Banana Cull samples from packinghouses

The draft January 1997 attached protocol was tentatively agreed upon. Glen Hersdale agreed to have PPQ supervisors in Kauai, Maui and Oahu aid in the collections of the culls. In February, J. Armstrong will visit these locations with PPQ and collect the culls from one to four farms per island. In April, June and August 1997 PPQ will collect and send samples from the same farms per J. Armstrong's instructions.

Issue #4: Forced infestation of green bananas under field conditions

The draft January 1997 attached protocol was tentatively agreed upon with an addition of a second series of tests.

In the additional series, unharvested bunches of bananas are identified that contain a few precociously ripened fruit. Those fruits are removed from the bunch and the remainder of the bunch are subjective to force field infestation as described in the protocol for field testing (Protocol attached).

In another series, the harvest of bunches of "Dwarf Brazilian" are delayed by one week and two weeks from the farmers' normal harvest time (Protocol attached).

Issue #5: Forced infestation of green bananas under laboratory conditions

The draft January 1997 attached protocol was tentatively agreed upon with an additional series of tests.

Issue #6: Purchase of color meter and/or Monsanto color charts.

At this time, PPQ does not know if color charts are needed. Hopefully, the research and survey will indicate that they are not needed. If ARS needs a color meter and the funding is not available, then we request this by memorandum to Glen Hensdale.

Issue #7: "Semiprocessed" Carambola

On January 21, 1997, the group visited Hula Brothers Carambola orchard and "processing plant". This visit was at the request of Ed Uyeda and Glen Hensdale. There are some concerns that the degree of processing of the carambola is not sufficient to remove the risk from fruit flies.

The processing consisted of five pounds of carambola slices between ½ inch and 1 inch thick being placed in a plastic bag. This fruit is then held and shipped under refrigeration at about 3 degrees C. The fruit was not in juices or other liquid medium and it was not vacuum packed.

Appendix E—Continued

This fruit is reported to be occasionally infested by the oriental fruit fly (OFF) and, in fact, Ed Uyeda found an infested fruit in the orchard fairly quickly.

The grower is sending only a few such shipments (one bag each) to the mainland, basically as a marketing test. He is also concerned about the degree of processing and knew that this probably will not be commercially feasible. ARS is planning to run some tests on mortality of OFF's eggs and larvae in a liquid. If this is allowed the product should be inspected at the 100 percent level for small shipments only and for a short duration until a less risky alternative is found.

Ed Miller

Charles E. Miller
Risk Analysis Systems
Policy and Program Development

Enclosures

cc:

Jack Armstrong, Hilo, HI, ARS
Ed Uyeda, Hilo, HI, PPQ
Glen Hensdale, Honolulu, HI, PPQ
Pete Grosser, Riverdale, MD, PPQ
Edwin Imai, Riverdale, MD, PPQ

Ed Imai needs to comment on the above issues and attached protocol if his review indicates a need.

s:/cmiller/Hibanan.wpd

Appendix F
PPQ Survey Data of Hawaiian Banana Shipments

Table I. Banana Growers Sampled on Hawaii Island, September 1996 through August 1997

Grower No.	Grower	Location	Acres in Production			
			Dwarf 'Brazilian'	'William's	'Valery'	'Grand Nain'
1	Rick Schuster	Keaau	4	2	6	...
2	Mike Tarring	Keaau	9	...	...	...
3	Allen Goodson	Keaau	...	3	...	...
4	Lynn Richardson	Kurtistown	2	8	7	0.75
5	Richard Ha	Keaau	35	417	...	20
6	Aka Ula Farms	Mountain View	5	7	...	...
7	Dwayne Whithworth	Keaau	8	8	...	...
8	Volcano Isle Fruit	Kapoho	2	7	...	0.5
9	Neal Bashford	Kapoho	10	25	...	...
10	Tim Law	Kalapana	8	4	4	...

Appendix F—Continued

Table II. Pests and Faults in Banana Shipments from, Hawaii Island, September 1996 through August 1997

Sample Lot No.	Grower No.	Boxes in Shipment	Cultivar[1]	Month	*Aspidiotus destructor*[2]	Poss. Tip Rot	Serious Fault or Organism[3]
1	1	104	B, V, W	9	Heavy	Yes	...
2	2	40	B	9	...	...	...
3	3	71	W	9	Heavy	...	...
4	4	100	G, V, W	9	...	...	...
5	5	100	W	9	...	Yes	...
6	5	384	W	9	Light	Yes	Ant
7	6	43	W	9	...	...	Ant
8	7	44	B	9	Heavy	...	...
9	8	72	W	10	...	...	...
10	5	384	C	10	...	Yes	...
11	5	384	C	10	...	Yes	...
12	4	250	B, G, V, W	10	...	...	...
13	2	70	B	10	...	Yes	Cockroach
14	3	66	W	10	...	...	...
15	1	71	B, V	10	Heavy	Yes	Cut (TS) (1)
16	5	227	W	10	...	Yes	Punctured (TS) (1)
17	5	336	C	10	...	Yes	...
18	8	60	C	11	Heavy	Yes	...
19	6	36	C	11	...	...	...
20	9	160	B, W	11	...	Yes	Punctured (TS) (1)
21	4	5	B	11	Heavy	Yes	Stage 3 (1) Ants, Earwig
22	4	84	B	12	Heavy	...	Earwig
23	1	108	B	12	Moderate	Yes	Crushed (1), Ant, Spider
24	5	18	B	12	Heavy	Yes	...
25	10	72	B, C	12	...	...	Ant, Cockroach
26	1	114	B, C	1	...	...	...
27	2	25	B	1	...	...	...
28	5	364	C	1	...	...	...
29	2	24	B	1	Heavy	...	Fused Fingers (1), Green scale, Ant
30	4	140	C	1	...	...	...
31	1	60	C	1	...	...	Fused Fingers (1)
32	8	60	C	2	...	...	Cluster between stage 2 and 3 (4)
33	10	8	B	2	...	Yes	...
34	5	180	C	2	...	Yes	Slug
35	6	30	B	3	Heavy	Yes	Spider
36	4	175	B, C	3	Heavy	Yes	Spider, Gnats
37	1	52	C	4	...	...	...
38	2	95	B	4	Heavy	...	...
39	5	384	C	4	Heavy	...	...
40	6	25	W	4	Light	Yes	Cockroach
41	3	50	W	5	Light	...	Adult Moth
42	9	75	B, W	5	...	...	*Pseudaulacaspis cockerelli* (1)
43	6	20	W	5	...	...	Cockroach (1)
44	10	30	B	5	Heavy	Yes	*Pseudaulacaspis cockerelli* (1)
45	4	48	B	7	Heavy	Yes	Earwig, Cockroach
46	3	75	W	7	Moderate	...	...
47	5	384	C	7	Moderate	...	...
48	1	60	C	7	...	...	...
49	4	40	C	7	Moderate	...	...
50	6	50	W	7	Heavy	...	Fused Fingers (1), Sowbug, *Saissetia nigra* (several fingers)
51	9	40	B	8	...	Yes	Earwig
52	5	384	C	8	Heavy	...	...

[1] B = Dwarf Brazilian, C = Cavendish, G = Grand Nain, W = Williams, V = Valery

[2] Light = *A. destructor* or probably *A. destructor* scales found on one cluster, Moderate = found on 2 clusters, Heavy = found on 3 or more clusters

[3] TS = through skin. The number in parentheses indicates the number of fingers affected

Appendix F—Continued

Table III. Organisms Identified from Banana Shipments, September 1996 through August 1997

Organism	Infested shipments	Federal Quarantine Status [1]	California Quarantine Status[2]
Ant (workers) (Formicidae)	6	No quarantine action required with banana fruit	Some counties will take action for worker ant[3]
Cockroach (Blattidae)	5	Non-reportable	C or Q depending on identification
Sowbug (Isopoda)	1	Non-reportable	C or D depending on identification
Moth (Lepidoptera)	1	Depending on identification	Depending on identification
Earwig (Dermaptera)	4	Non-reportable	C or Q depending on identification
Spider (Araneae)	3	Non-reportable	D
Aspidiotus destructor (Diaspididae) coconut scale	24	Non-reportable	A
Pseudaulacaspis cockerelli (Diaspididae) magnolia white scale	2	Non-reportable	A
Coccus viridis (Coccidae) green scale	1	Reportable	Q
Saissetia nigra (Coccidae) a black scale	1	Non-reportable	C

[1] Reportable pest requires Federal quarantine action at least under certain situations. A non-reportable organism requires no Federal quarantine action.

[2] California pest ratings are:

A—Eradication, quarantine, or other holding action at the state-county level.
B—Intensive control or eradication, where feasible, at the county level. Quarantine or other holding action at the discretion of the commissioner.
C—Control, eradication, as local conditions warrant at the county level. Quarantine or other holding action at the discretion of the commissioner.
D—No control or quarantine action at county level.
Q—Rejection of infested material or the pest as such when found in a quarantine shipment.

[3] Pers. commun. 1997, Dorothea Zadig, California Department of Food and Agriculture.

Appendix F—Continued

Table IV. Inspection Summary

Inspection Data	Number/Units	
Shipments inspected		
Dwarf Brazilian	15	
Cavendish	29	
Mixed shipments	8	
Total	52	
Average clusters inspected per box		
Dwarf Brazilian	8	
Cavendish	7	
Average fingers inspected per box		
Dwarf Brazilian	48	
Cavendish	44	
Approximate number inspected	Clusters	Fingers
Dwarf Brazilian	1,472	8,832
Cavendish	2,303	14,476
Total	3,775	23,308
Shipment destination		
Honolulu, Oahu	41	
Maui	1	
Hilo	8	
Not reported	2	

Table V. Shipments with Serious Faults

Shipment	To	Fault
Brazilian	Oahu	Fused fingers (one)
	Oahu	Crushed (one fingers)
	Hawaii Island	Ripeness stage 3 (one finger)
Cavendish	Hawaii Island	Fused fingers (one)
	Oahu	Fused fingers (one)
	Hawaii Island	Punctured (through skin) (one finger)
	Oahu	Punctured (through skin) (one finger)
	Oahu	A cluster between ripeness stage 2 and 3 (four fingers)

Appendix G

United States Department of Agriculture
Agricultural Research Service
Pacific West Area
Tropical Fruit, Vegetable and Ornamental Crops Research Laboratory
PO Box 4459
Hilo, HI 96720
telephone: (808) 959-4336
fax: (808) 959-4323 / -5470

October 6, 1997

SUBJECT: Export of Mature Green Hawaii-grown Cavendish Bananas to Other Areas of the United States

TO: Charles E. Miller, Senior Entomologist
APHIS, PPQ, PRAS
Riverdale, MD

THROUGH: Kenneth W. Vick, National Program Leader,
ARS, NPS
Beltsville, MD

FROM: Jack Armstrong, Research Entomologist
Hilo, HI

Pursuant to my September 10, 1997, memorandum to you regarding the results of our meeting that same day to review data from our banana host status tests in Hawaii, I am forwarding one copy each of the packing house cull banana sample results for Cavendish bananas (specifically the 'Valery' and 'Williams' cultivars) and my 1983 publication, *Infestation biology of three fruit fly (Diptera: Tephritidae) species on 'Brazilian,' 'Valery,' and 'William's' cultivars of banana in Hawaii.*

These two documents are submitted to APHIS for consideration in allowing the export of Hawaii-grown Cavendish bananas to other areas of the United States without quarantine treatment against fruit flies (i.e., as a non-host). The results of our continuing research on the 'Brazilian' cultivar of banana will be submitted later if the results of field infestation tests conclusively show that this cultivar also is a non-host for Mediterranean fruit fly and oriental fruit fly.

I enclosed the research outline for collecting the banana cull samples from packing houses for your information, and the results for the Cavendish cull samples are found in Table 2 (attached to the research outline). Table 1 (not enclosed) contains the data for 'Brazilian' bananas. Please call me or send a fax to the above numbers, or email me at jwa@aloha.net if you have any questions.

Appendix H*

Table 1. Culled dwarf 'Brazilian' bananas sampled from cull dumps at packing houses on the islands of Hawaii, Kauai, Maui, Molokai, and Oahu

Banana fault (damage type)	Number of bananas with fault sampled	Number of fault type infested with fruit flies	Percent of sample infested with fruit flies	Number of adult fruit flies recovered from infested bananas[a]	Number of dead fruit fly pupae recovered from infested bananas[a]	Number of bananas infested with *Opogona sacchari* (Bojer)	Percent of sample infested with *O. sacchari*	Number of *O. sacchari* recovered from infested bananas
Cut	608	7	1.15	132	88	13	2.14	29
Split	115	1	0.87	16	13	4	3.48	8
Crushed	172	4	2.33	89	43	6	3.49	11
Abrasion	1,367	7	0.51	8	1	31	2.27	117
Precocious ripening	224	53	23.66	423	429	5	2.23	11
Point bruise or scar	1,253	3	0.24	17	5	28	2.23	60
Tip rot	786	0	0.00	0	0	4	0.51	6
Thrips scar	790	0	0.00	0	0	13	1.65	17
Ant burn	477	2	0.42	5	0	10	2.10	15
Scale insect[b]	304	0	0.00	0	0	3	0.99	5
Chemical burn	50	0	0.00	0	0	4	8.00	7
Sunburn	134	0	0.00	0	0	0	0.00	0
Stem bend[c]	378	8	2.12	46	23	2	0.53	26
Puncture[c]	574	1	0.17	53	56	11	1.92	27
Puncture[d]	503	0	0.00	0	0	10	1.99	16
Crack[c]	251	6	2.39	19	12	2	0.80	20
Crack[d]	55	0	0.00	0	0	1	1.82	2
Windburn	5	0	0.00	0	0	0	0.00	0
Bird peck	1	0	0.00	0	0	0	0.00	0
Deformed fruit[e]	391	0	0.00	0	0	10	2.56	16
Decay (general)	313	0	0.00	0	0	5	1.60	10
Total	8,751	92	1.05	808	670	162	1.85	403

[a] Only oriental fruit fly, no Mediterranean fruit fly or melon fly, was recovered from bananas with faults
[b] Three bananas were found infested with mealybugs; live armored scales were found occasionally
[c] Bend causing splitting of skin to expose fruit flesh; puncture through skin into fruit flesh; crack exposing fruit flesh
[d] Puncture or crack not completely through skin to expose fruit flesh
[e] Two or more banana fingers fused together

* Tables from Armstrong 1998

Appendix H*—Continued

Table 2. Culled Cavendish ('Grand Nain', 'Valery', and 'Williams' cultivars) bananas sampled from cull dumps at packing houses on the islands of Hawaii, Kauai, Maui, Molokai, and Oahu

Banana fault (damage type)	Number of bananas with fault sampled	Number of fault type infested with fruit flies	Percent of sample infested with fruit flies	Number of adult fruit flies recovered from infested bananas[a]	Number of dead fruit fly pupae recovered from infested bananas[a]	Number of bananas infested with *Opogona sacchari* (Bojer)	Percent of sample infested with *O. sacchari*	Number *O. sacchari* recovered from infested bananas
Cut	298	0	0.00	0	0	2	0.67	5
Split	160	3	1.88	0	9	3	1.88	8
Crushed	182	4	2.20	1	39	2	1.10	6
Abrasion	623	3	0.48	0	9	12	1.93	32
Precocious ripening	31	5	16.13	42	56	0	0.00	0
Point bruise or scar	334	3	0.90	0	29	11	3.29	19
Tip rot	139	0	0.00	0	0	2	1.44	2
Thrips scar	127	0	0.00	0	0	6	4.72	11
Ant burn	15	0	0.00	0	0	0	0.00	0
Scale insect[b]	5	0	0.00	0	0	1	20.00	3
Chemical burn	35	0	0.00	0	0	1	2.86	1
Sunburn	41	0	0.00	0	0	0	0.00	0
Stem bend[c]	63	0	0.00	0	0	3	4.76	5
Puncture[c]	160	0	0.00	0	0	4	2.50	14
Puncture[d]	113	0	0.00	0	0	2	1.77	7
Crack[c]	10	0	0.00	0	0	0	0.00	0
Crack[d]	41	0	0.00	0	0	0	0.00	0
Windburn	0	0	0.00	0	0	0	0.00	0
Bird peck	3	0	0.00	0	0	0	0.00	0
Deformed fruit[e]	14	1	7.14	2	14	2	14.29	2
Decay (general)	23	0	0.00	0	0	0	0.00	0
Total	2,417	19	0.79	45	156	51	2.11	115

[a] Only oriental fruit fly, no Mediterranean fruit fly or melon fly, was recovered from bananas with faults
[b] Three bananas were found infested with mealybugs; live armored scales were found occasionally
[c] Bend causing splitting of skin to expose fruit flesh; puncture through skin into fruit flesh; crack exposing fruit flesh
[d] Puncture or crack not completely through skin to expose fruit flesh
[e] Two or more banana fingers fused together

* Tables from Armstrong 1998